Miniature directional coupler with different dielectric parameters

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Miniature directional coupler with different dielectric parameters

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Abstract. A study aimed at identifying the effect of substrate parameters such as dielectric permittivity and thickness on the characteristics of directional couplers, whose dimensions are reduced by means of compact structures. It was found that with the increase in the thickness of the substrate in a compact coupler increases the frequency band and the degree of miniaturization, and with increasing dielectric constant Vice versa.

1. Introduction

In the development of directional couplers it is important to consider what is the impact of a particular parameter of the microwave substrate on its characteristics. This is especially important in the design of compact couplers, since in this case the substrate material can affect the degree of miniaturization, frequency band, and loss. Various compact structure applied with the purpose to reduce the dimensions of the microstrip taps with a minimum deterioration in its characteristics. Compact structures consist of a set of inductances and capacitances. The literature has already described many works concerning the miniaturization of taps, consider only some of them, in [1] proposed to reduce the size using quasi-concentrated elements, in [2] equivalent transmission lines, in [3] U-shaped capacitances, in [4] periodic capacitive loads, asymmetric T-shaped structures in [5], low-pass filters in [6,7,8], slow-down systems in [9,10], artificial transmission lines in [11-13], fractal structures in [14,15], in [16] high-resistance elements, in [17] loaded loops, in [18-21] interdigital capacitors. These works and the structures described in them are made on a variety of dielectrics. Therefore, in this paper we will investigate the influence of parameters such as the dielectric constant and the thickness of the microwave dielectric.

2. Design

The study was carried out on a standard model of a coupler with two loops. Its topology operating at a frequency of 2 GHz and calculated in a specialized program is shown in Fig.1. The frequency characteristics of the coupler modeled on a substrate with a dielectric constant of 4.4 and a thickness of 1 mm are shown in Fig.2.3.

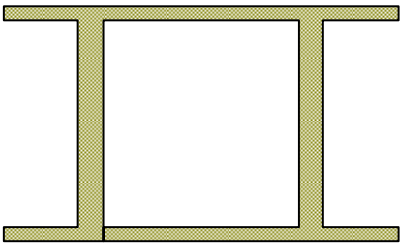

Figure 1. Topology directional coupler

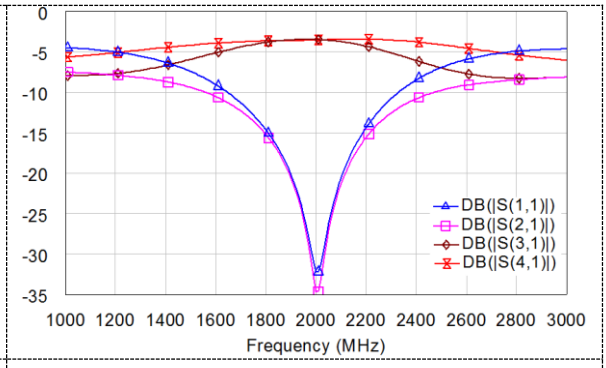

Figure 2. S-parameters from frequency

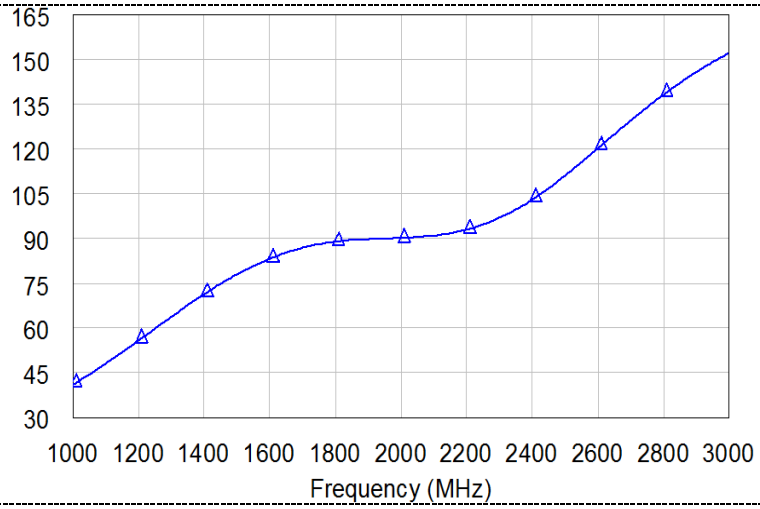

Figure 3. Phase on frequency

The same topology and characteristics were obtained for the dielectric constant of 2.5, 3.4, 4.4 and 5.5 for the thickness of 1 mm. And then with dielectric constant 4.4 with thickness of the substrate 1, 1.5 and 2 mm. This was done to obtain data for later comparison with compact taps. For Fig.4 shows the compact structure and a quarter wavelength segment, and figures 5, 6 show their characteristics.

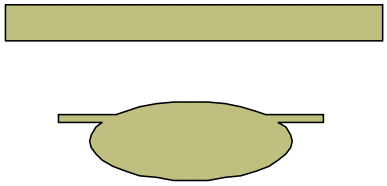

Figure 4. Topology of a quarter-wave segment and a compact structure with an impedance of 50 Ohm

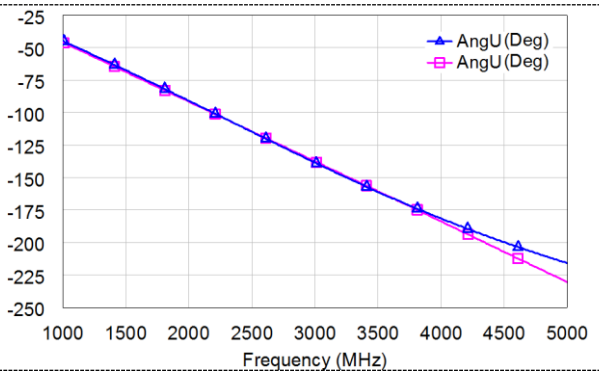

Figure 5. Phase on frequenc

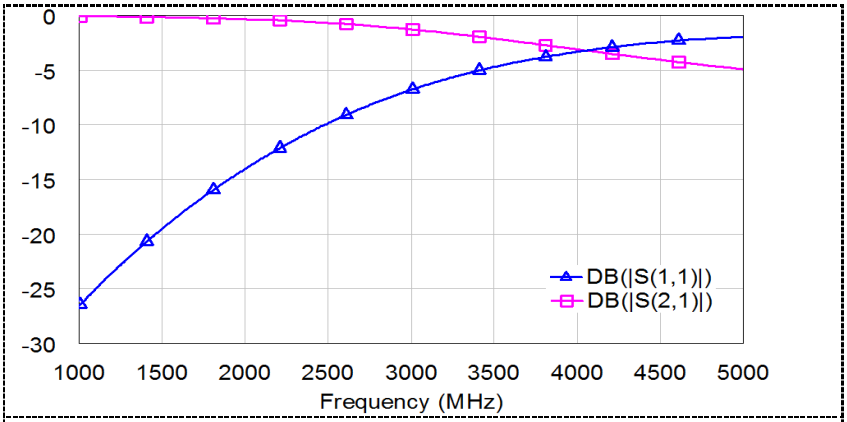

Figure 6. Frequency characteristics of a compact structure

The compact coupler on the substrate e=5.5 and h=1 mm is shown in figure 7, and its frequency characteristics are illustrated in Fig.8.

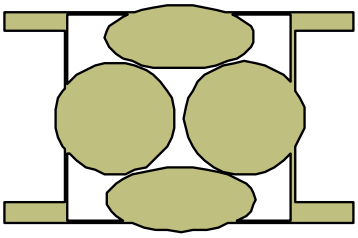

Figure 7. Compact coupler topology

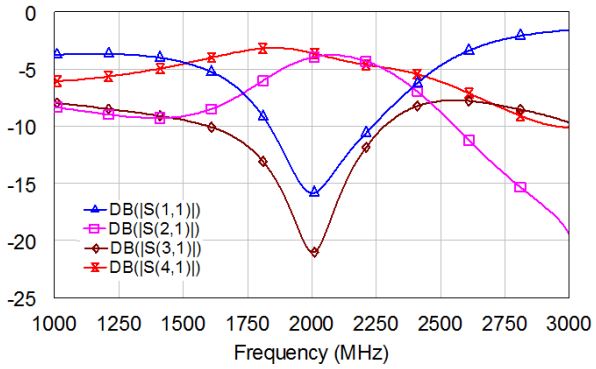

Figure 8. S-parameters from frequency

The compact coupler on the substrate e=4.4 and h=1 mm is shown in figure 9, and its frequency characteristics are illustrated in Fig.10.

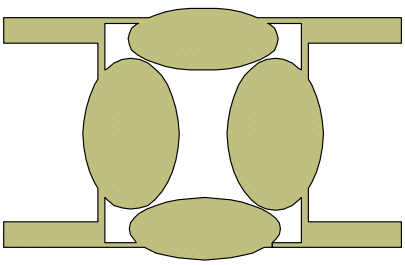

Figure 9. Compact coupler topology

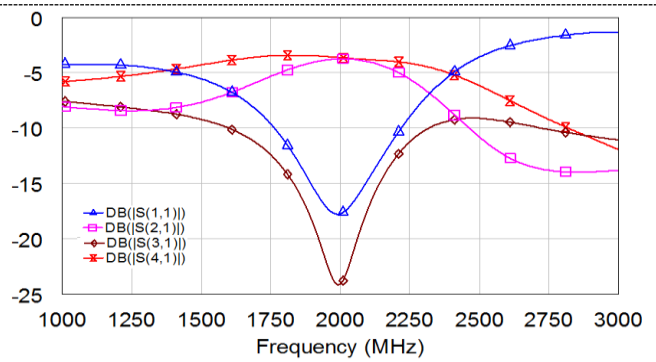

Figure 10. S-parameters from frequency

The compact coupler on the substrate e=3.4 and h=1 mm is shown in figure 11, and its frequency characteristics are illustrated in Fig.12.

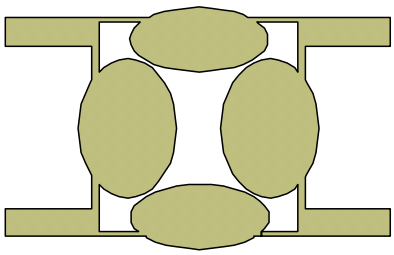

Figure 11. Compact coupler topology

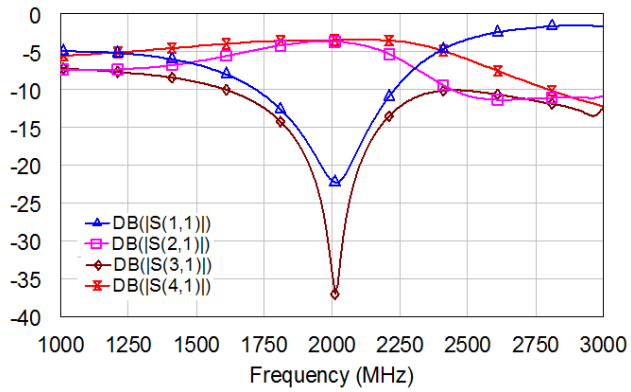

Figure 12. S-parameters from frequency

The compact coupler on the substrate e=2.5 and h=1 mm is shown in figure 13, and its frequency characteristics are illustrated in Fig.14.

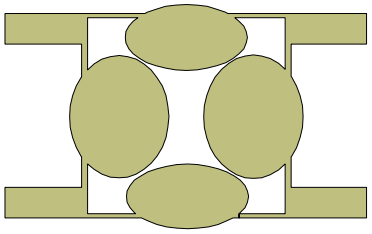

Figure 13. Compact coupler topology

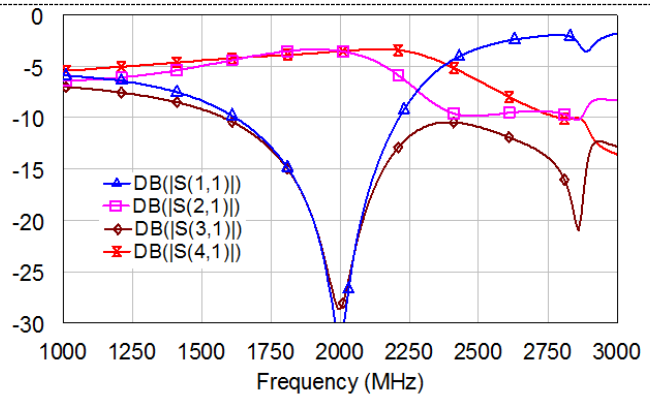

Figure 14. S-parameters from frequency

The compact coupler on the substrate e=4.4 and h=1.5 mm is shown in figure 15, and its frequency characteristics are illustrated in Fig.16.

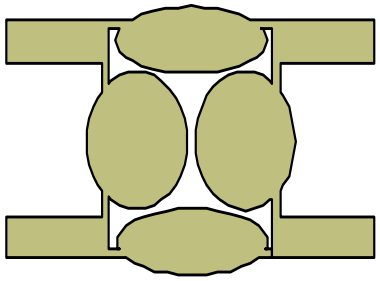

Figure 15. Compact coupler topology

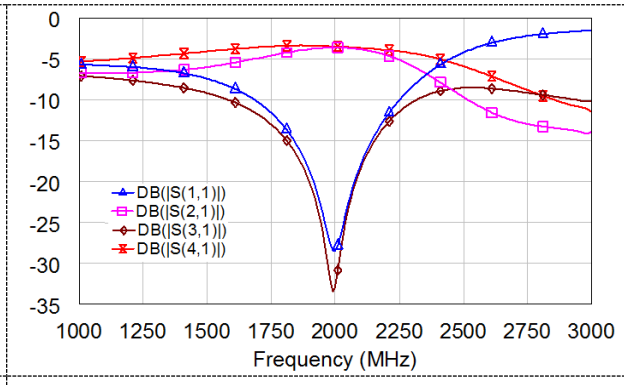

Figure 16. S-parameters from frequency

The compact coupler on the substrate e=4.4 and h=2 mm is shown in figure 17, and its frequency characteristics are illustrated in Fig.18. All the results were listed in table 1.

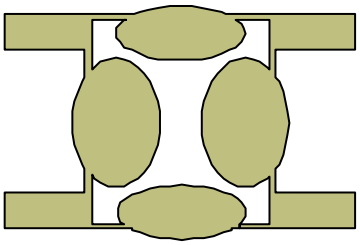

Figure 17. Compact coupler topology

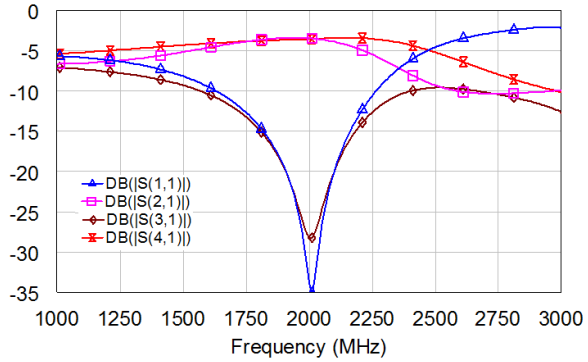

Figure 18. S-parameters from frequency

Table 1. Comparison of coupler

Substrate	Design	Area, mm2	Bandwidth, MHz	Reduce area, % / Reduce bandwidth %
E =2.5	Standard	1037	226	58%
H=1mm	Compact	435	176	22%
E =3.4	Standard	786	225	52.2%
H=1mm	Compact	376	186	17.3%
E =4.4	Standard	628	225	47%
H=1mm	Compact	332.9	140	37%
E =5.5	Standard	512	224	48%
H=1mm	Compact	265.3	80	64%
E =4.4	Standard	753	220	49.5%
H=1.5mm	Compact	380.65	177	19.5%
E =4.4	Standard	875	215	56.5%
H=2mm	Compact	381.5	194	9.7%

3. Conclusion

As a result of the study, it was found that the degree of miniaturization is affected by the dielectric constant and thickness. So the thicker the substrate, the higher the percentage of miniaturization of the design area, as well as in a wider frequency band, the operating frequency band remains at the level of 20 dB decoupling. With increasing dielectric constant miniaturization efficiency decreases as the area decreases, and to preserve the characteristics of the device.

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